Brazil-China-India meeting on HVDC and Hybrid Systems, planning and Engineering Issues

Rio de Janerio, Brazil
July 16th-18th, 2006

HVDC Systems Planning Considerations

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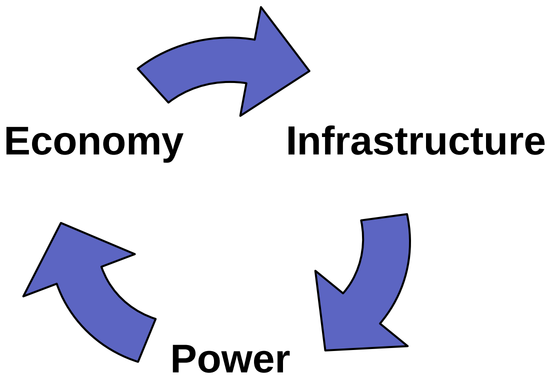
Dilemma for the Emerging Economies

Rapid economic growth → Continued Infrastructure development → Power Demand

- **Growth Circle**



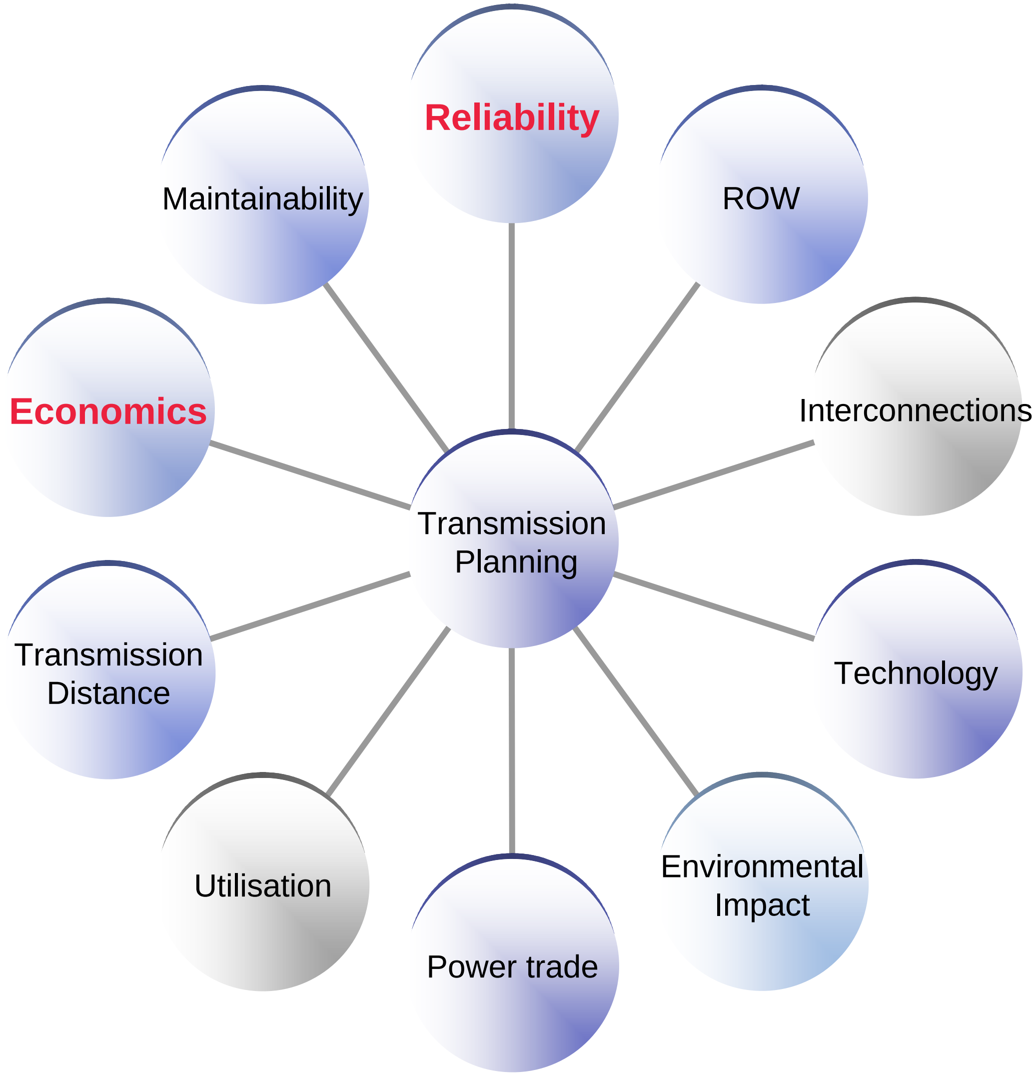
- **Murphy's law (Law of Nature) →** Cheap power generation source always farthest away from the loads.
  - BULK POWER TRANSFERS OVER LONGER DISTANCES

New challenges for transmission systems

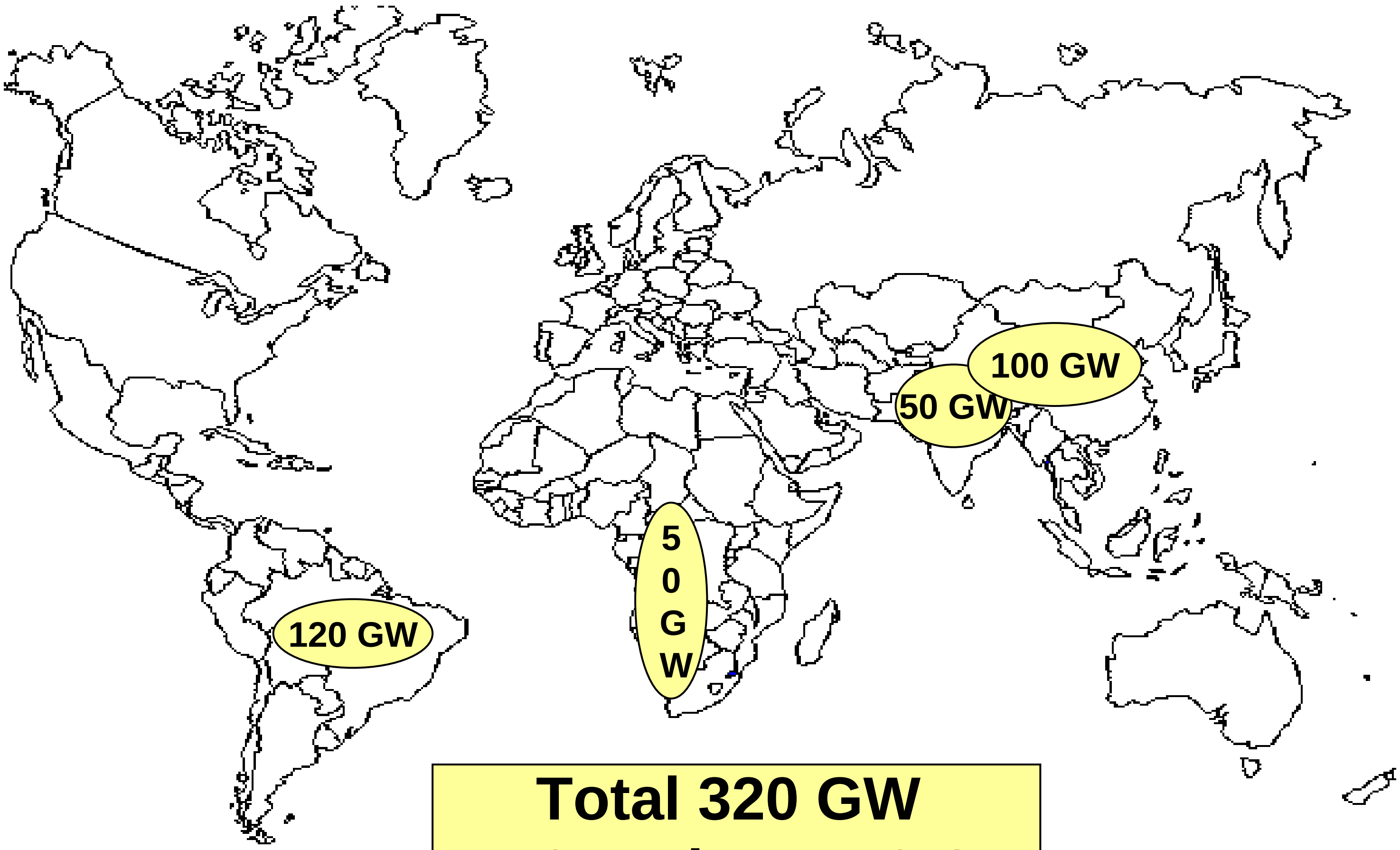
- **Important aspects from perspective of Developing countries**
  - Reliable Bulk power transmissions over larger distances
  - Value for Money
  - Minimal Environmental Impact
  - Assistance in economic development of new areas
  - Power cuts and Black outs - Intolerable to economic growth
  - Increasing the efficiency of existing Power grid
  - Power quality

ABB

Planning considerations for Bulk Power Transmission

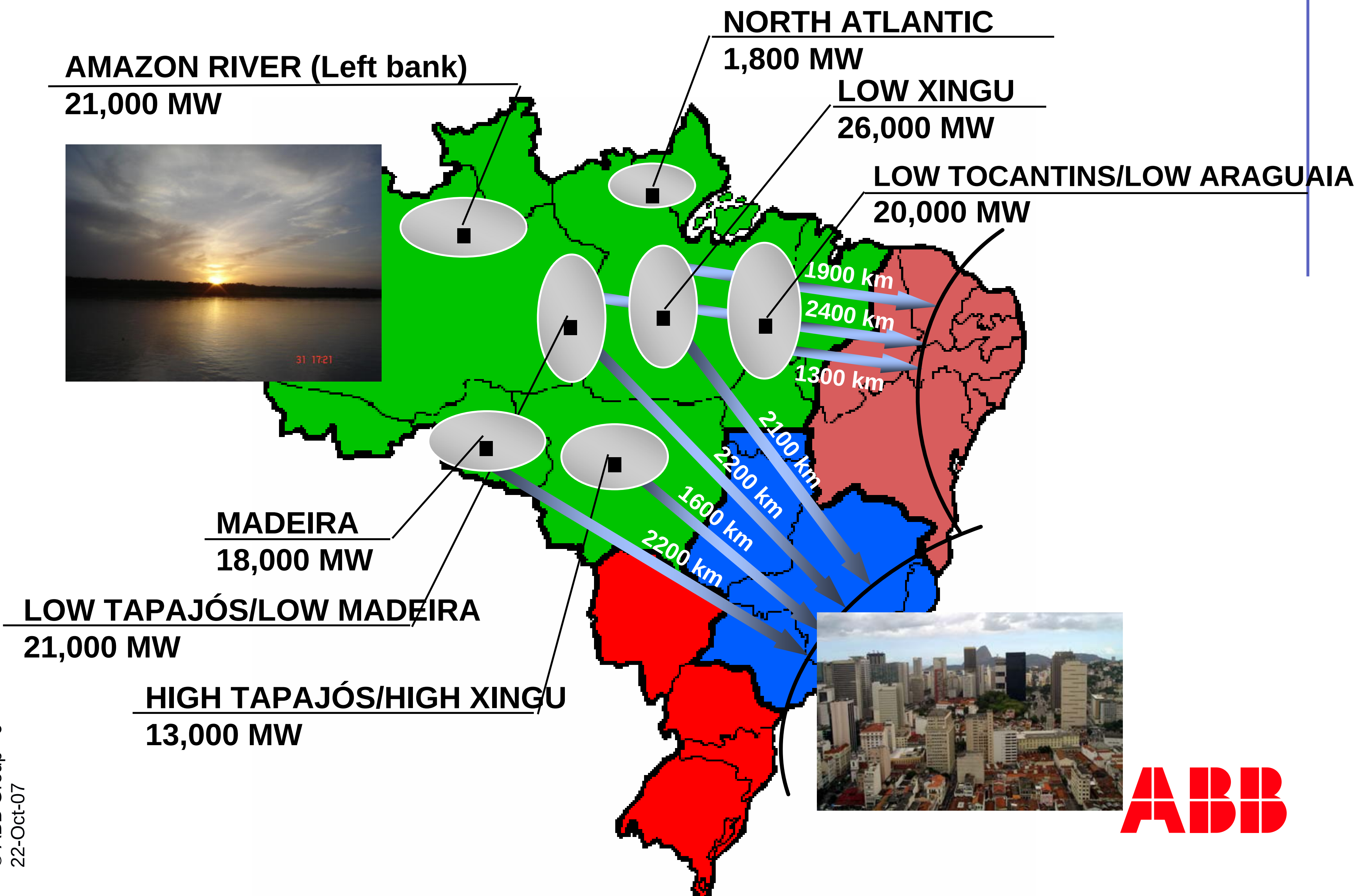


Potential 800 kV HVDC projects in the world

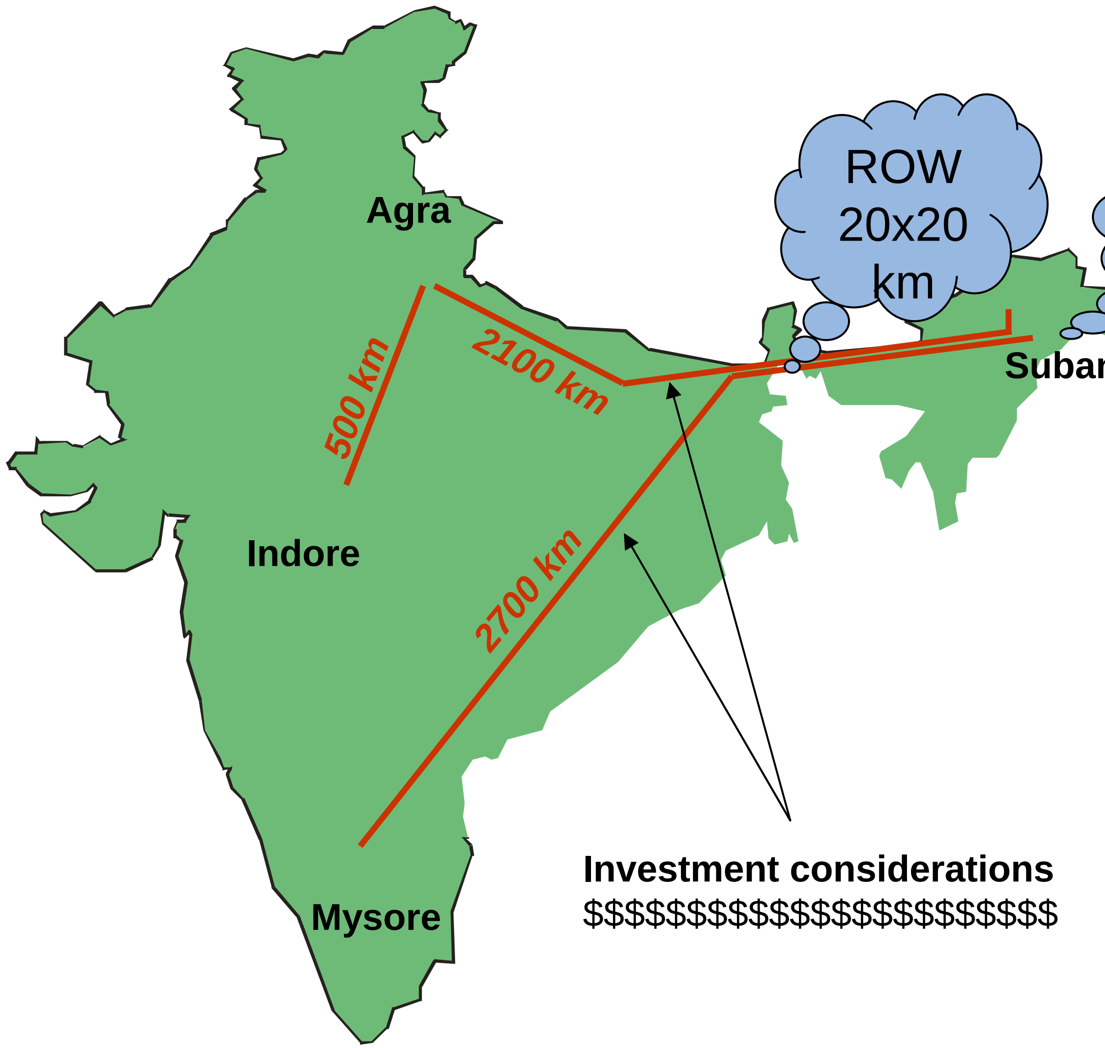


Total 320 GW
= 50 projects * 6 GW

Brazil: Potential Amazonas River Projects



Brahmaputra River Hydro Power Development



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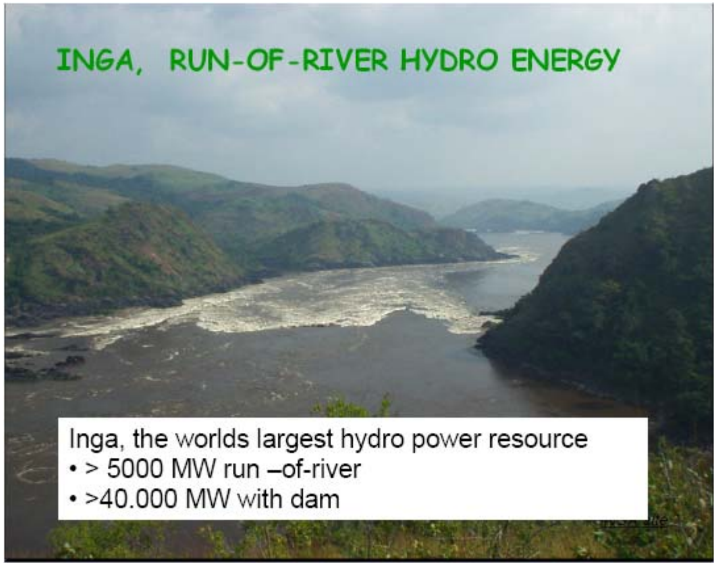
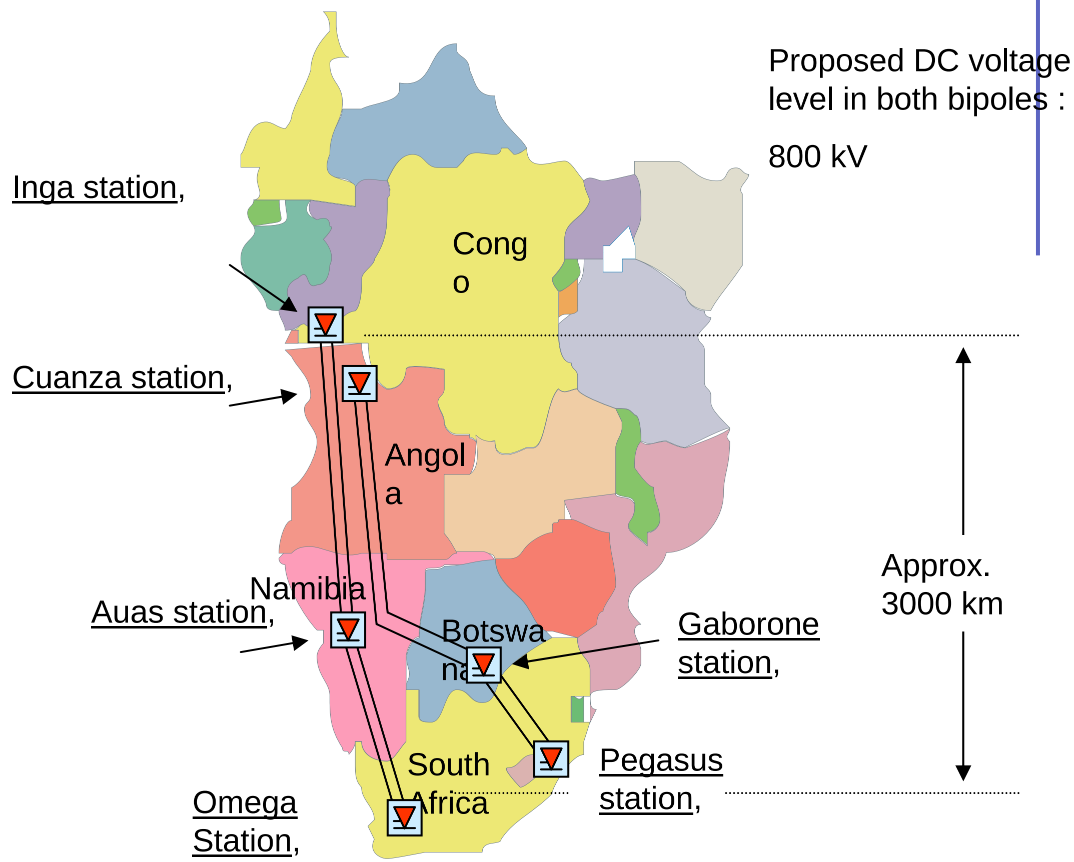
South Africa: West Cor Line





Jinsha River I (Xiluodu, Xiangjiaba), Jingping & Xiaowan Dams, for 800kV UHVDC

Updated 2006-4-14, CNABB-PTSG

Xiangjiaba – Shanghai

800kV, 6400 MW, 1950km
2011

Xiluodu – Hubei (C.China)

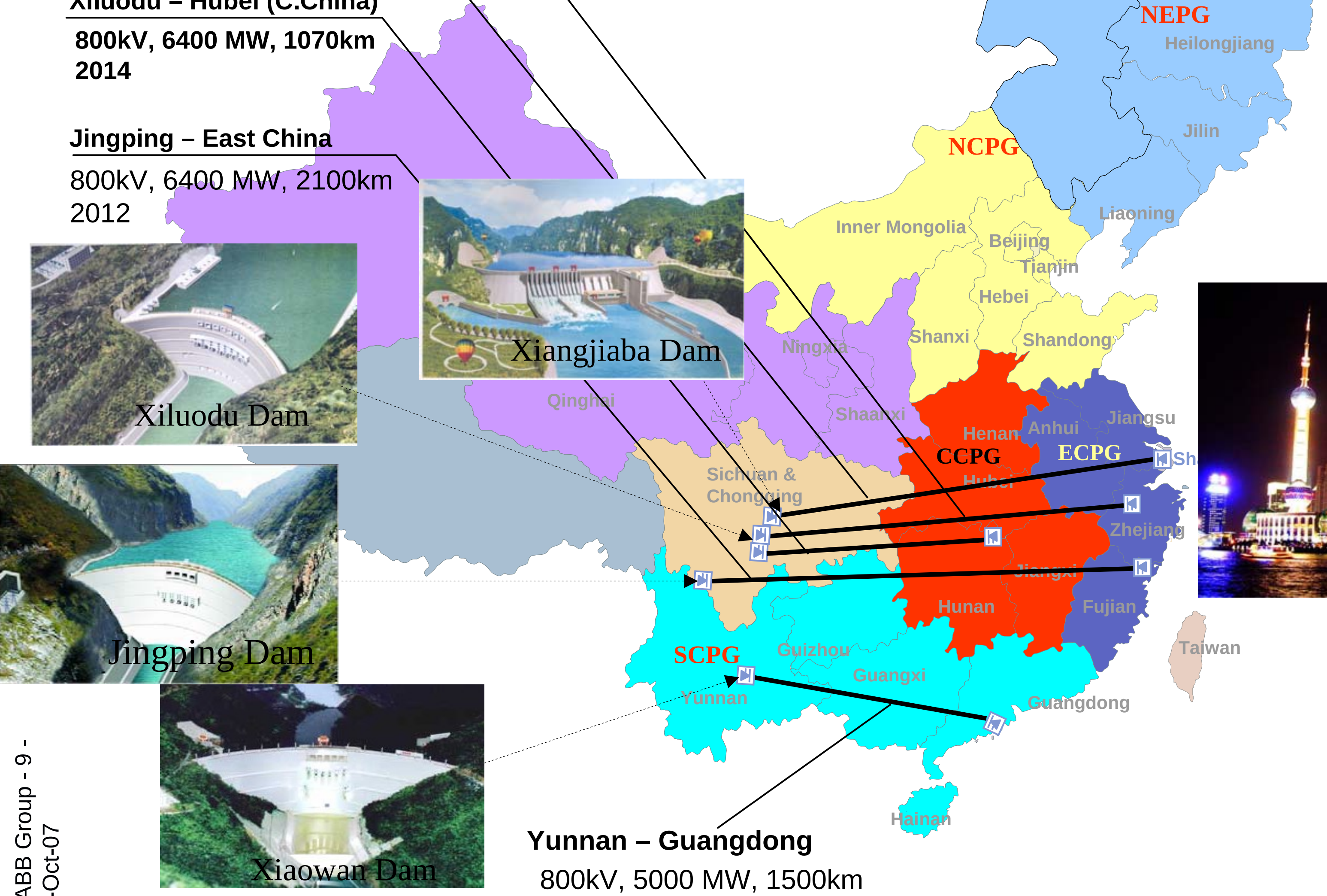
800kV, 6400 MW, 1070km
2014

Jingping – East China

800kV, 6400 MW, 2100km
2012

Xiluodu – Zhejiang

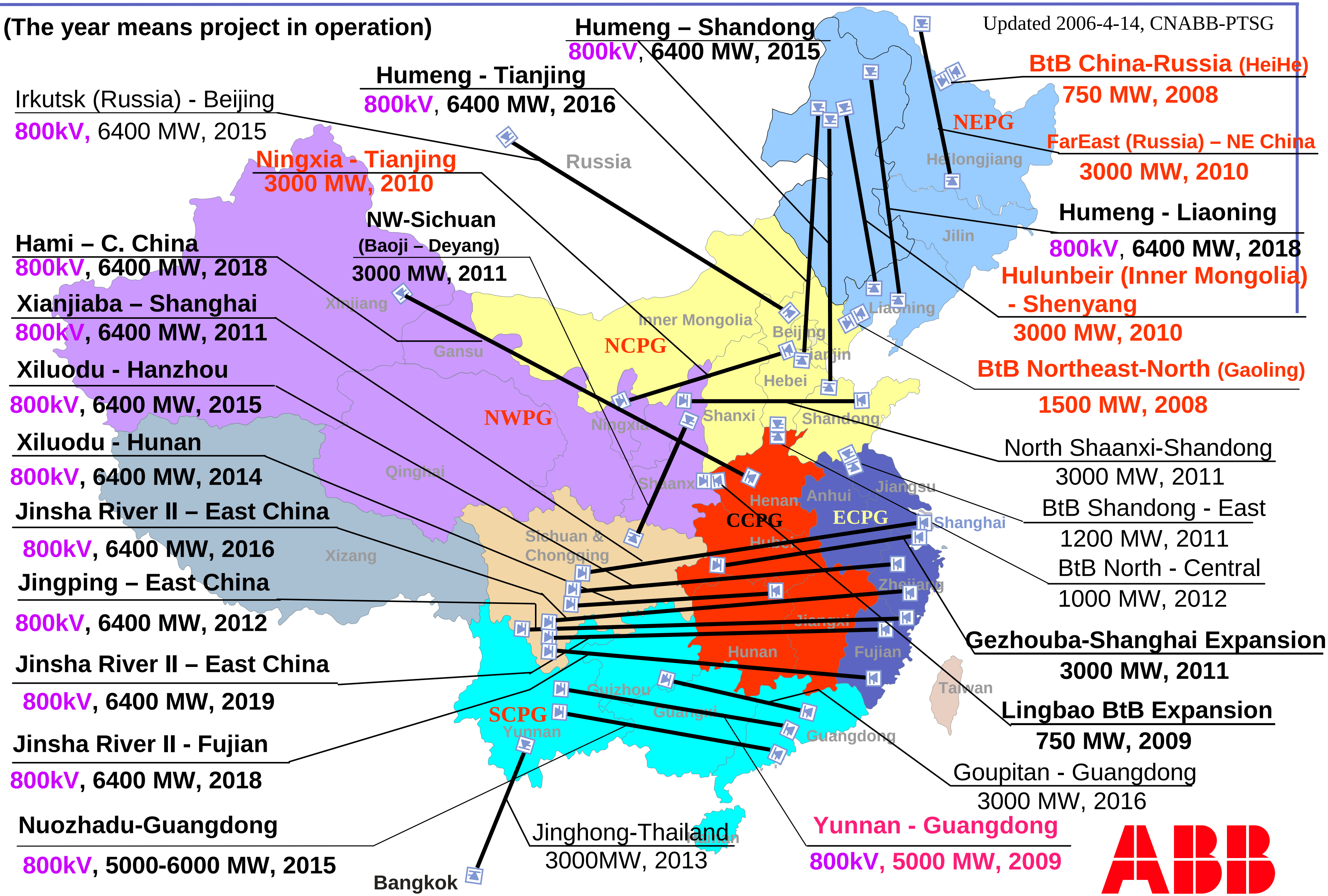
800kV, 6400 MW, 1870km
2015



Yunnan – Guangdong

800kV, 5000 MW, 1500km
2009

Planned Future HVDC Projects by 2020 in China



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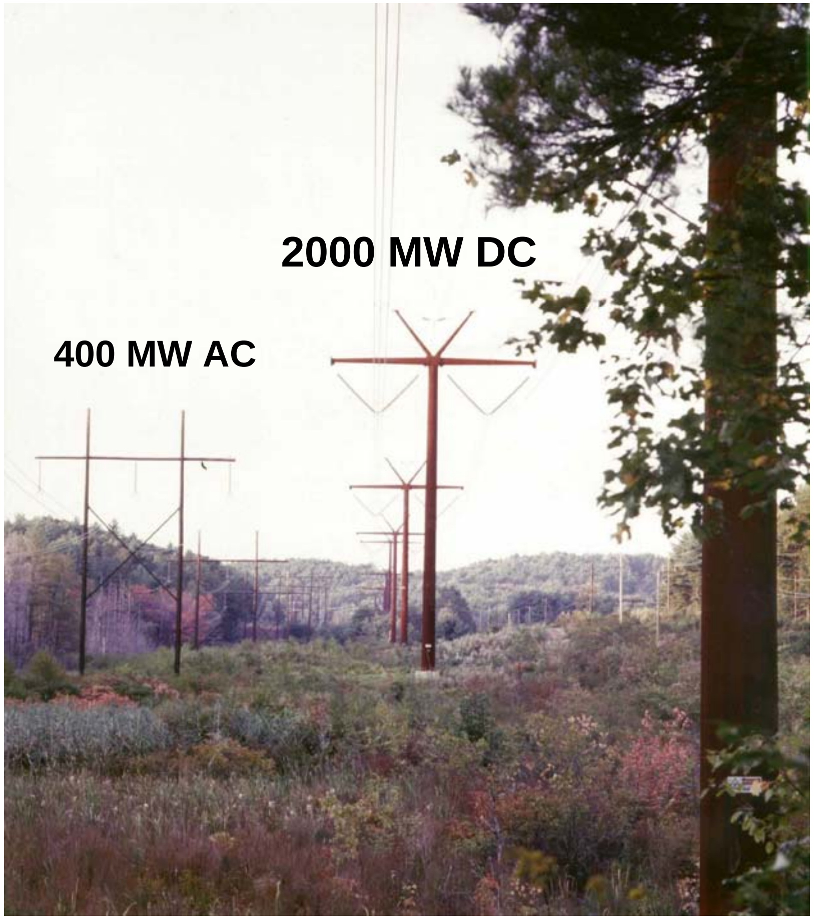
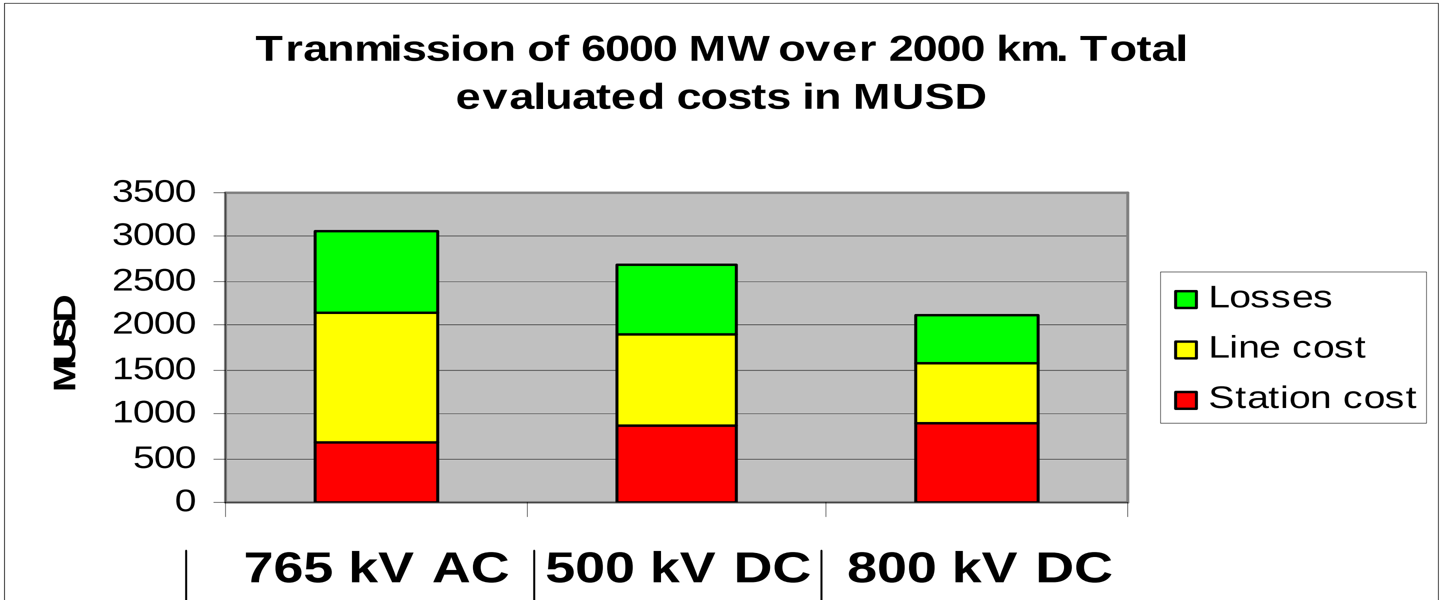
What makes UHVDC an obvious choice

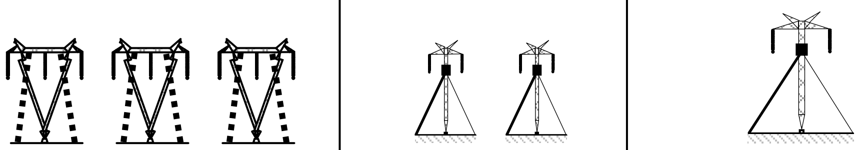


- Typically over such larger distances, there aren't any existing direct corridors for transmission.
- An AC interconnection would be technically extremely challenging and economically unviable

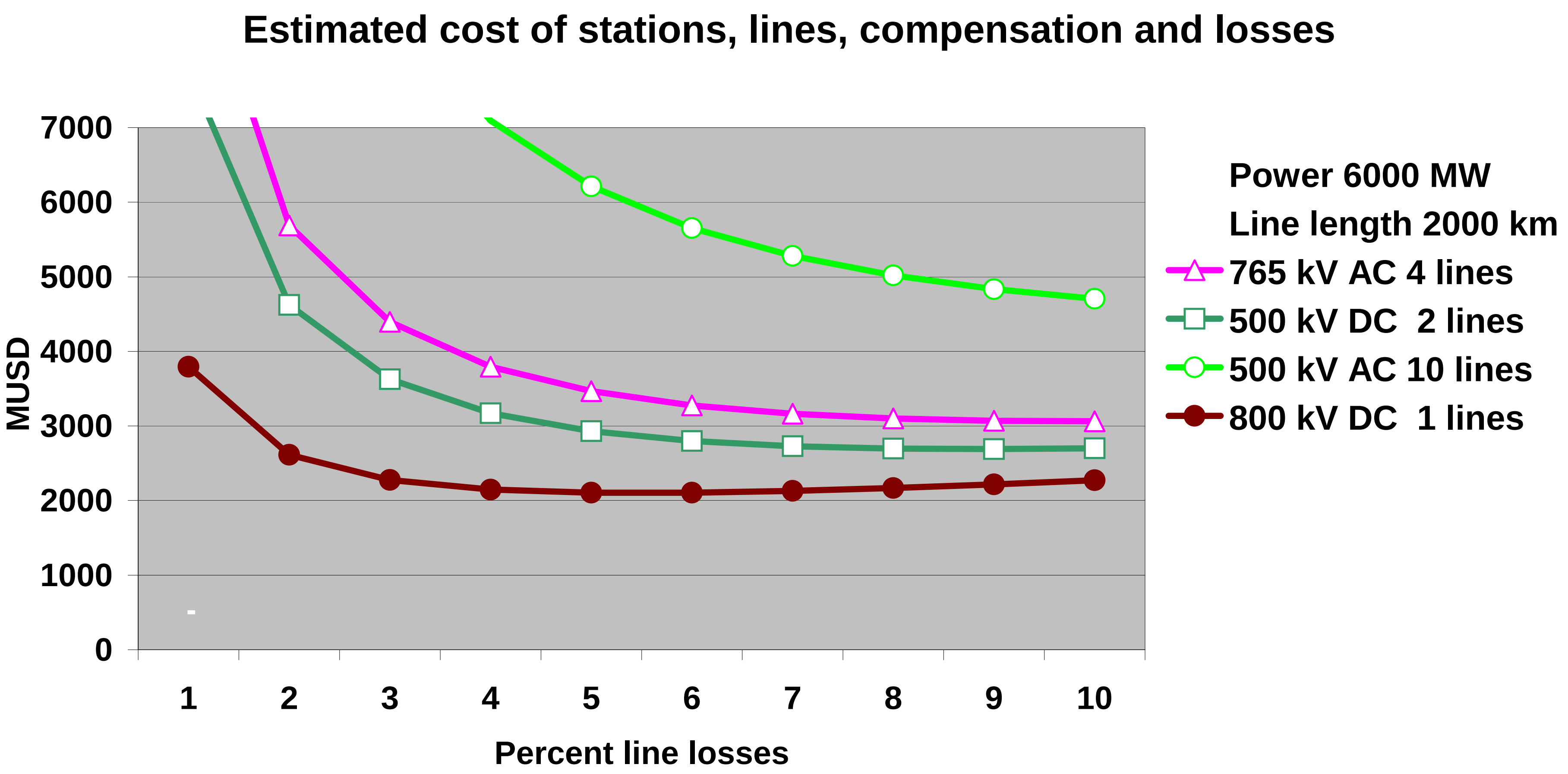
Economics

Transmission Economics

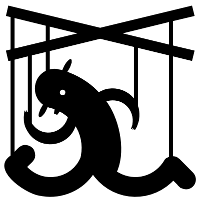


	765 kV AC	500 kV DC	800 kV DC
Number of lines:			
Right of way (meter)	**~240**	**~ 110**	**~ 90**

Transmission Economics



Why do we need HVDC links in a grid ?



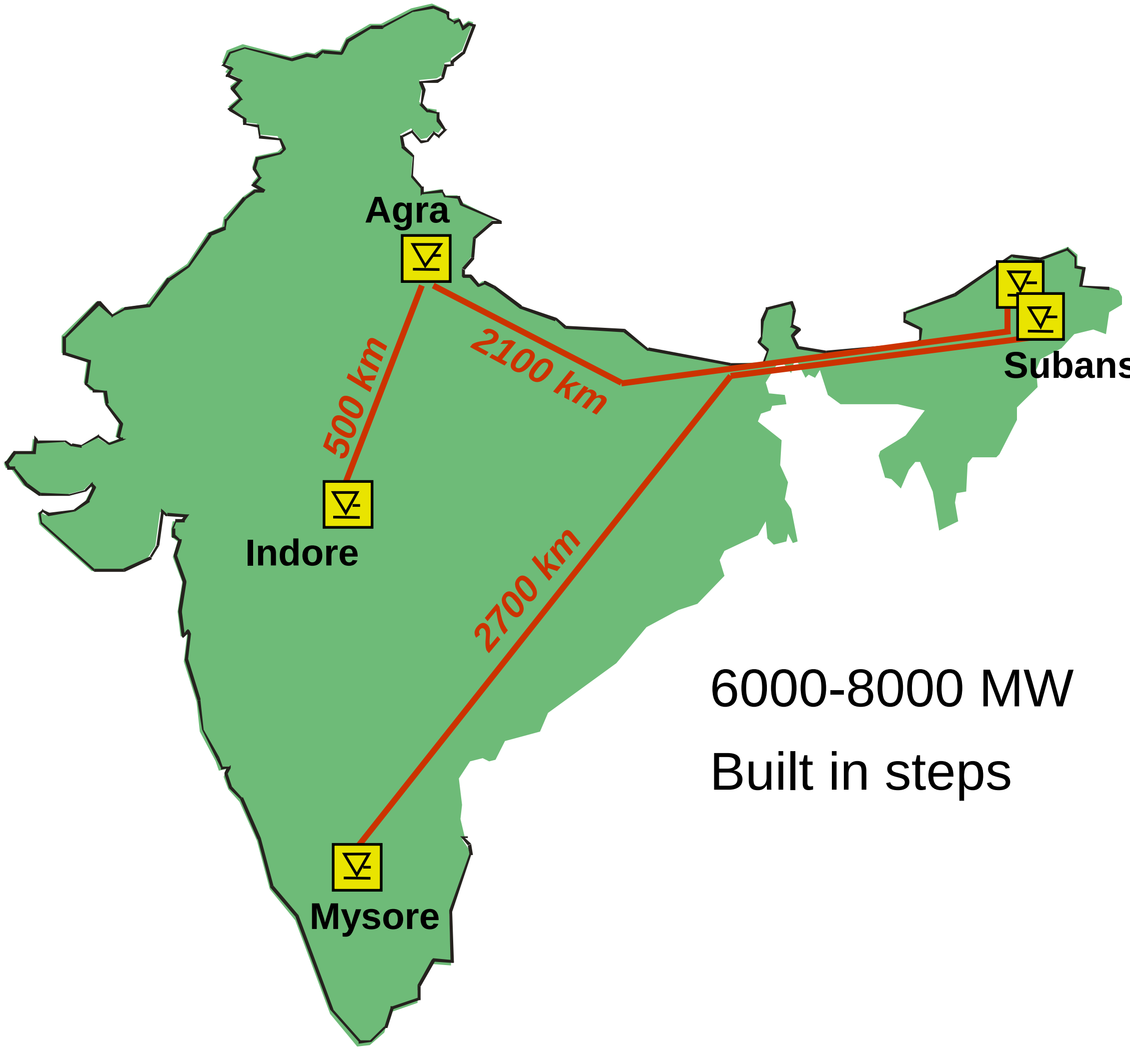
- Control rather than Be Controlled
  - Gives much more flexibility to the grid operators.
  - Through the controlling facility that HVDC offers, an increase in power via the AC lines can be permitted without jeopardising the stability of the network.
- Support to Existing AC corridors
  - Reactive power support / Voltage Support.
  - Frequency Stabilisation.
  - Control Features- Run Up / Run Down Power.
  - Interaction via SSC (system stability control).

Transmission line corridor

HVDC cables

Suggested Configurations

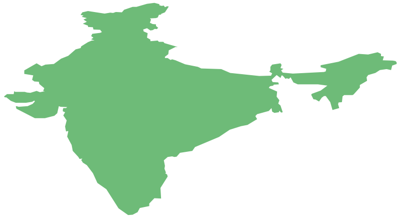
UHVDC plans - India

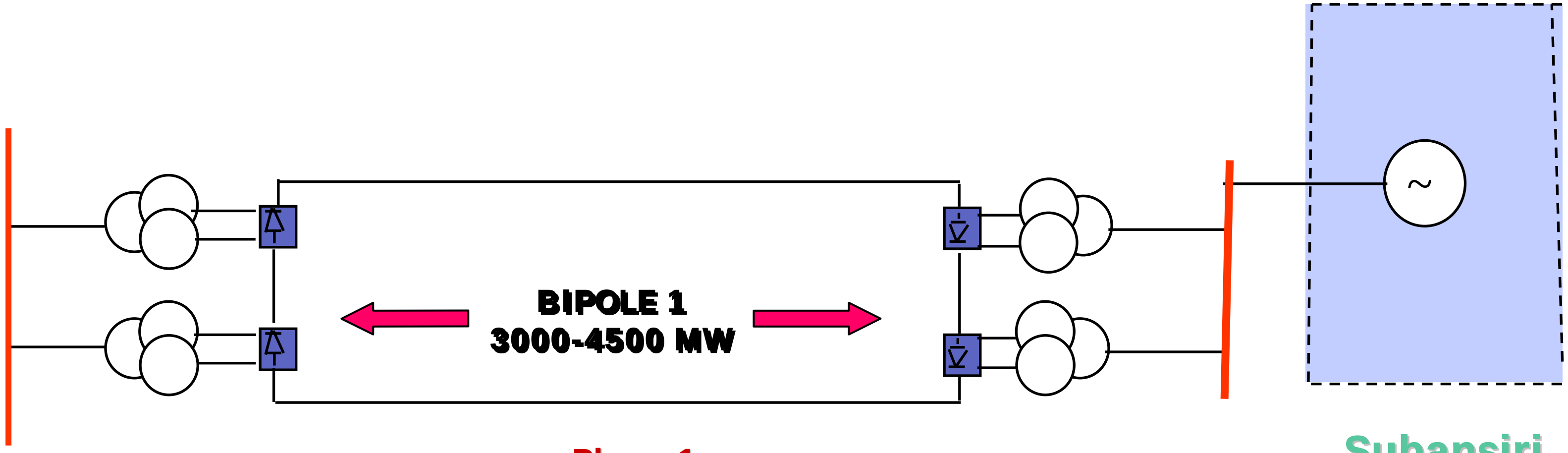


6000-8000 MW   +/- 800 kV

Built in steps

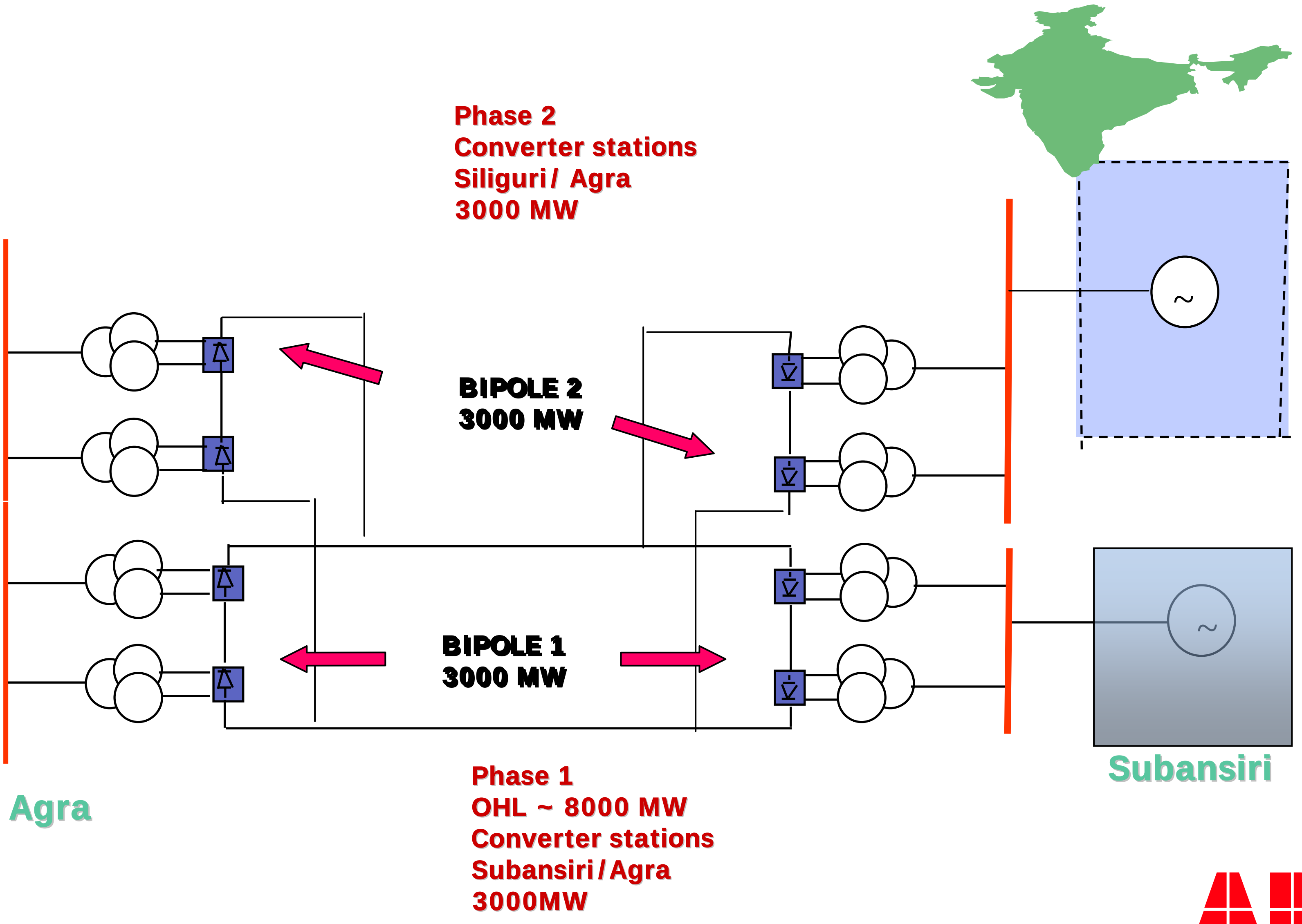
Parallel converters. Single 12 pulse bridge for each pole. 800 kV over the bridge. Phase 1.



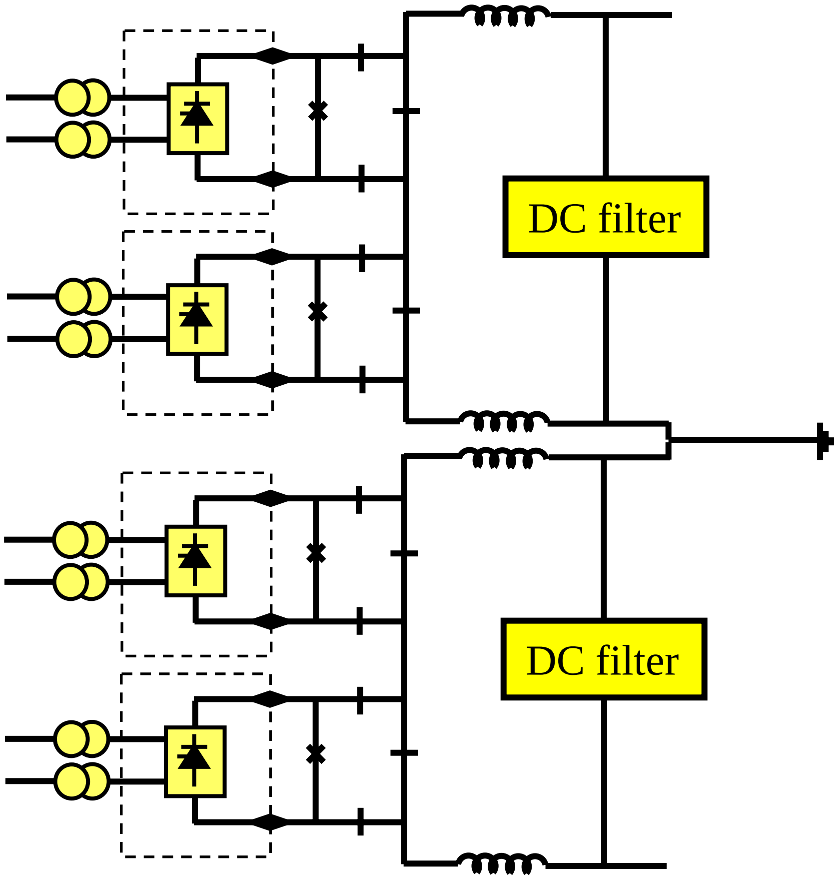


Phase 1
OHL Subansiri / Agra ~ 8000 MW
Converter stations
Subansiri / Agra
3000-4500 MW

Parallel converters. Single 12 pulse bridge for each pole. 800 kV over the bridge. Phase 2.

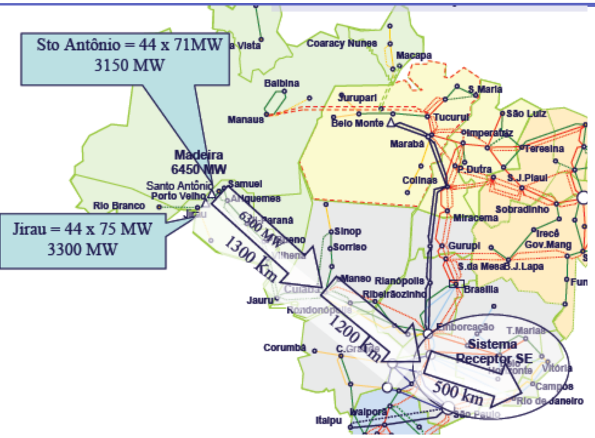


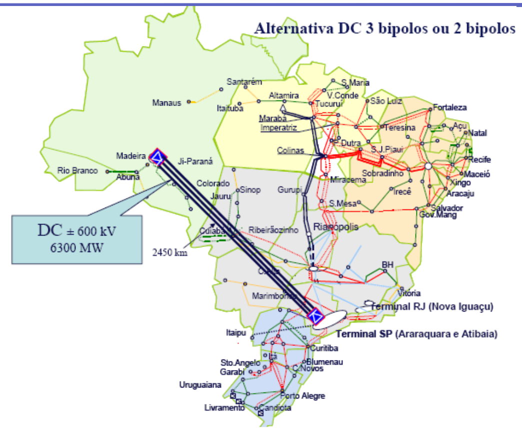
Series Connected converters – Chinese Plans

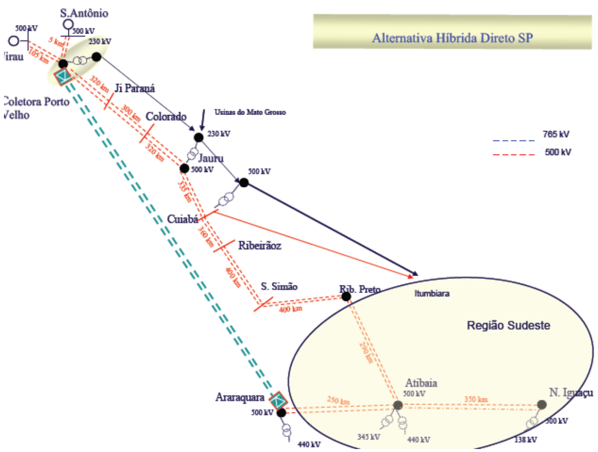


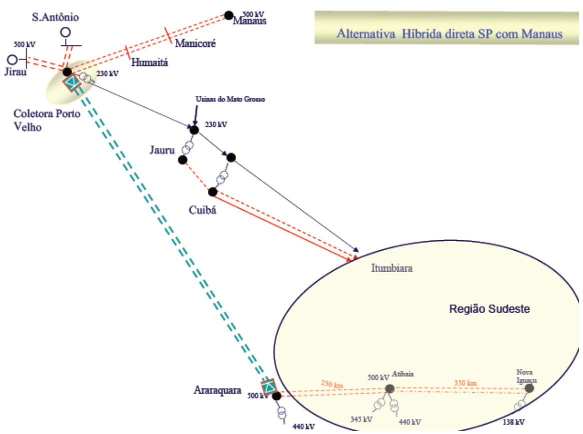
- **Two 400kV, 12 pulse groups/pole**
- **Transformer data**
  - **Nº 24 units**
  - **1Ø2W ~ 248 MVA**
- **Smoothing inductance split in pole and neutral**
- **Scheme: two converters per pole:**
  - **Installed at Itaipú, In operation for 20 years**

Transmission Alternatives

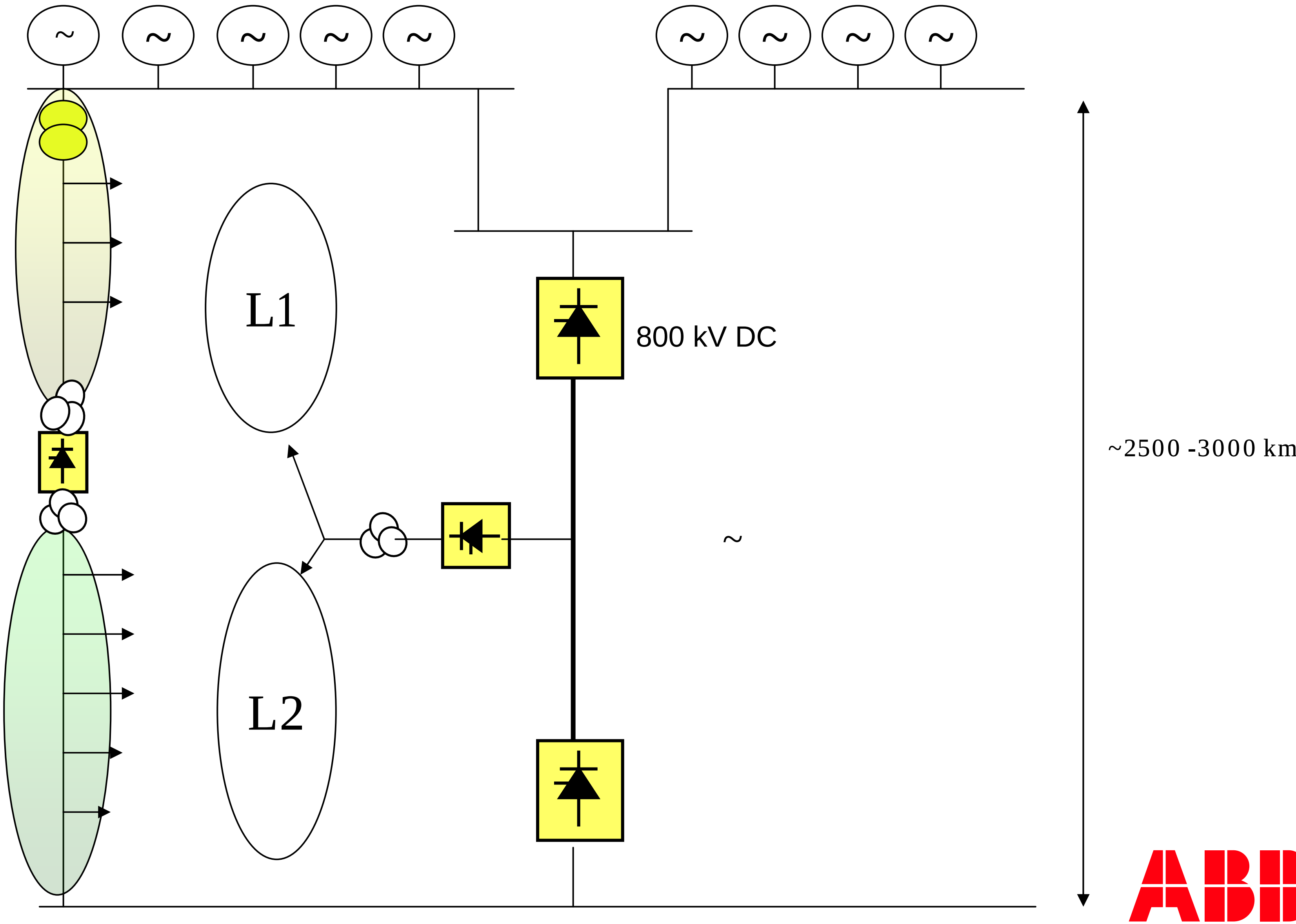




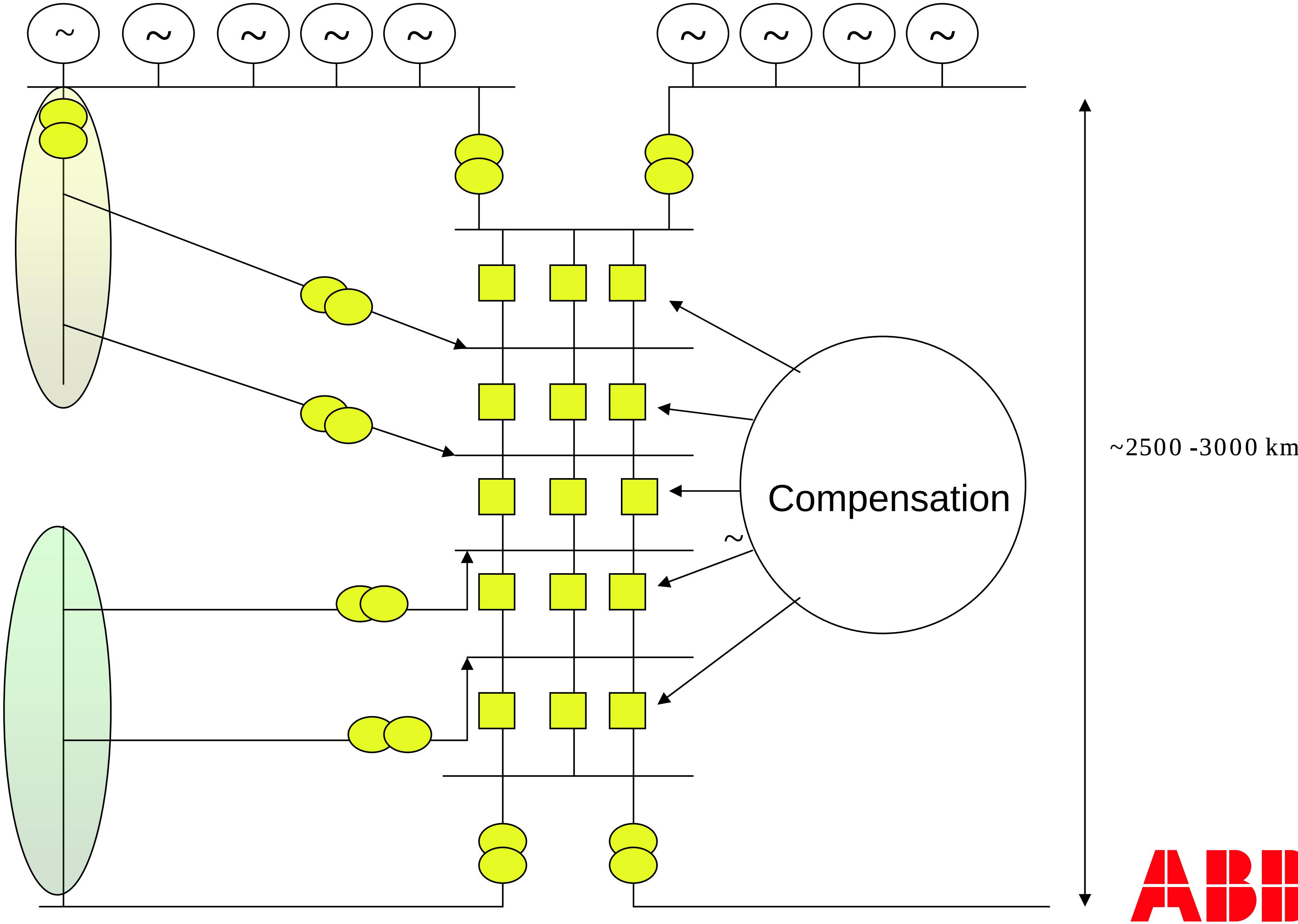




Transmission alternatives – Hybrid with UHVDC and HVDC Light®

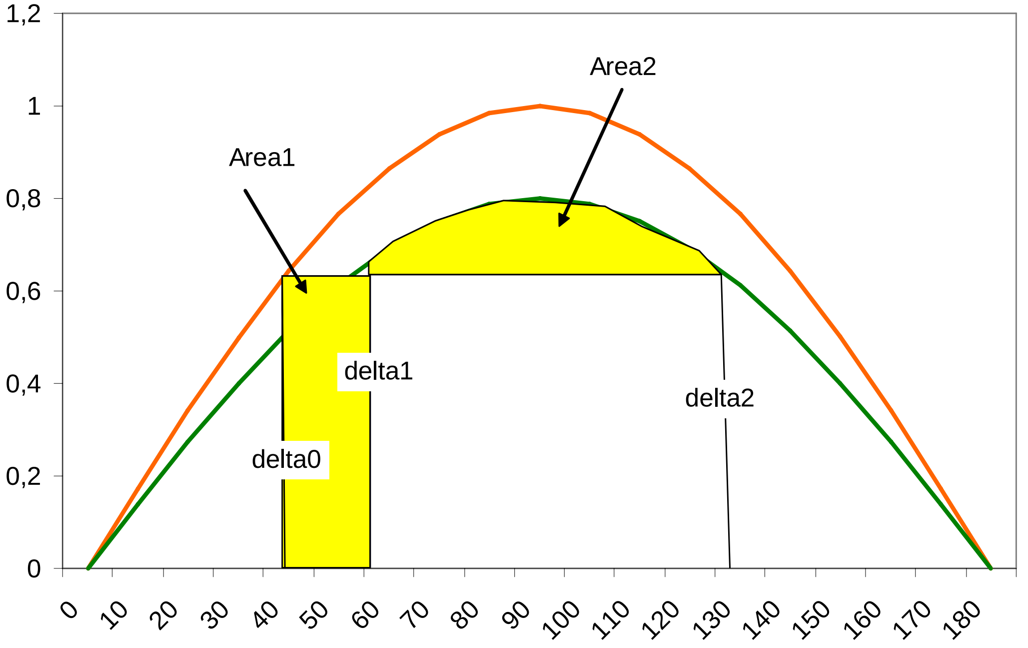


Transmission alternatives - EHVAC



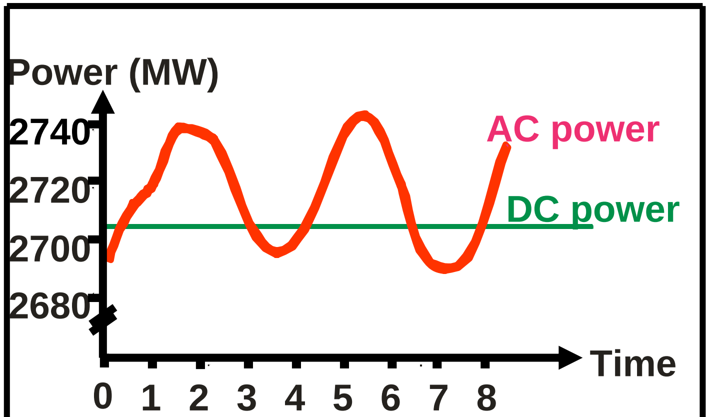
Stability Issues

The ac-system should not be loaded more than it can safely withstand the loss of any line or generator

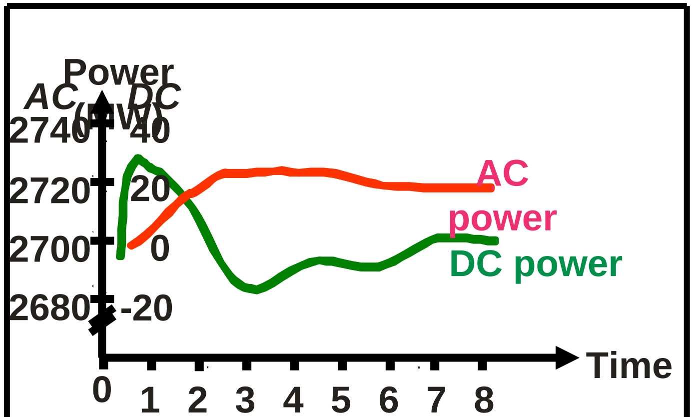


Stability Issues

- ”Bulk Power through Pure DC link” is more robust and provides considerable isolation and hence system stability due to the inherent independence from system phase angles.
- Also in Hybrid solutions , the DC link will stabilise the parallel AC transmission

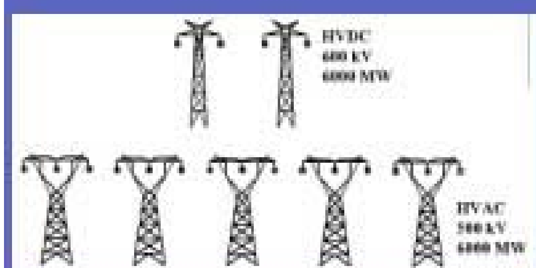


Without modulation of DC link



With modulation of DC link

Itaipu - A valuable Hybrid experience



Technology step taken 2 decades ago

Customer needs

- Long distant energy link between the hydro power generation in Foz do Iguaçu to the power consumption in the Sao Paulo area

ABB's response

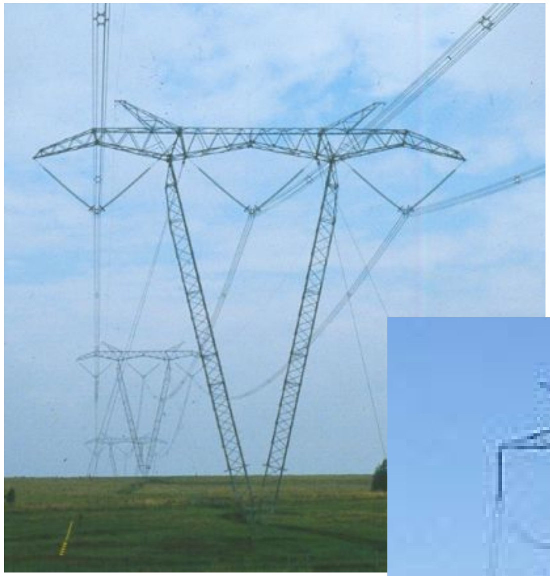
- Turnkey 6300 MW HVDC in two bipoles
- Highest +/- 600 kV DC voltage in the world

Customer benefits

- Itaipu project is serving as an important link for electricity
- Compact lines with low losses
- Security of supply through controllable power flow and redundancies

Itaipu - Overhead line reliability

Year	HVDC 600 kV		HVAC 765 kV		
#	1	2	1	2	3
1993	2	3			
1994	4	4			
1995	1	0	4	11	-
1996	0	0	13	7	-
1997	6	2	6	13	-
1998	2	2	10	16	-
1999	0	2	27	10	-
2000	2	0	15	14	9
2001			4	8	5
2002			12	7	16


765 kV AC


± 600 kV DC

HVAC 765 kV: 1.2 permanent fault/100 km/year

HVDC 600 kV: 0.2 permanent fault/100 km/year

ITAIPU HVDC SYSTEM : Availability

Converter Bipoles Availability Performance

Year	1988-91 (average)	1992	1993	1994	1995	1996	1997	1998	1999	2000
• **Bipole 1 %**										
Forced Unavailability	**1,9**	**0,25**	**0,18**	**0,35**	**0,05**	**0,23**	**0,86**	**0,03**	**0,22**	**0,05**
Scheduled Unavailability	**8,5**	**8,80**	**2,59**	**6,39**	**2,03**	**1,90**	**2,10**	**1,23**	**2,55**	**2,24**
CIGRE Availability	**89,6**	**90,9**	**97,2**	**93,2**	**97,9**	**97,9**	**97,0**	**98,7**	**97,2**	**97,7**
Contract Availability		**99,5**	**99,1**	**99,3**	**99,4**	**99,5**	98,9	99,7	99,5	99,7
• **Bipole 2 %**										
Forced Unavailability	**11,3**	**0,67**	**0,19**	**0,23**	**0,49**	**0,09**	**0,13**	**0,61**	**0,71**	**0,05**
Scheduled Unavailability	**10,2**	**6,40**	**2,50**	**5,92**	**2,12**	**1,23**	**1,54**	**1,23**	**1,28**	**2,64**
CIGRE Availability	**76,5**	**92,9**	**99,3**	**93,9**	**97,4**	**98,7**	**98,3**	**98,2**	**98,0**	**97,3**
Contract Availability		**98,9**	**99,4**	**99,4**	**99,3**	**99,6**	99,6	99,1	99,0	99,7

Summary

- Necessity to have a technically viable and economical means to transmit Bulk Power over large distances was the driving force for R and D of 800 kV UHVDC technology.

- It’s now clear that UHVDC technology is far superior for Point to Point Bulk Power transfers over long distances.

- UHVDC technology is READY FOR COMMERCIAL USE !

Avoid National waste

- There are various ways to avoid PASS THROUGH traffic !!

Or

City Bypass

Fly-Overs

Power and productivity
for a better world™